

Some Aspects of Reproduction of Mokihana (*Pelea anisata* Mann) in the Forests of Kōke'e¹

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THE GENUS *Pelea* (Rutaceae) has 70 species, of which all but 2 are endemic to the Hawaiian Islands (Stone 1969). Although they do not form pure stands, they are nevertheless important components of Hawaiian forests. *Pelea anisata* Mann is known to the Hawaiians as Mokihana and is distinctive because of the aniselike odor imparted to the plant by phenolic constituents (Scheuer 1955). It is one of 26 species of *Pelea* endemic to the island of Kaua'i, and is found in the Kōke'e, Waimea, and upper Hanalei regions at elevations of 1000–1340 m (Stone 1969). Mokihana is symbolic of this island, where today the fruit is strung into leis. In the past, the leaves were used as a mixture for coughs and colds (Heller 1897), and the twigs and capsules were employed as perfumes and scents for tapa (Rock 1913).

The cultural significance of *Pelea anisata*, along with its contribution to the native Hawaiian forests, led to the author's interest in the status of Mokihana reproduction. It, along with so many other native species, is faced with invasion of the persistent blackberry (*Rubus penetrans*) and other exotics. Also, the effect of human activity on reproduction is of concern, as trees are almost totally stripped of fruit for lei making in many areas. Although there is a law forbidding commercial picking, nothing prevents private use. This investigation is aimed at determining whether *P. anisata* is successfully reproducing in the face of harvesting and competition by introduced plants, and whether reproduction is principally by seed or through vegetative means.

MATERIALS AND METHODS

Seven areas were chosen within the Kōke'e–Waimea region; these areas were surveyed between May and October 1976. The criteria for site selection were moderately easy access and abundance of *Pelea anisata*. Three areas were specifically chosen because the presence of fruit on the trees indicated little or no harvesting, and it was assumed that the natural seed supply persisted. These were on the outer boundary of the Alaka'i Swamp, off Waininiua Trail and off Honopū Trail (Table 1). Four other sites were chosen along the accessible Kumuela Road and Po'omau Canyon Trail, where few trees had fruit remaining. A transect was marked through a stand of Mokihana trees in each area. Square plots, 3 m in each dimension, were staked out in pairs, one on each side of the transect, and spaced along the transect with their centers at 6-m intervals. The height and diameter of each Mokihana tree in the plots was measured and the survey was continued until approximately 100 individuals were recorded. Heights exceeding 3 m were pooled and recorded as 3 m, as these were assumed to be mature trees. The trees branch extensively at the base, and numerous suckers were noted. Thus, stems spaced 6 inches or less from the base of a tree were arbitrarily treated as part of that tree. Small trees spaced greater than 6 inches from the presumed parent plant were considered separate individuals. The latter could have been offspring of runners from the parent, but superficial excavation to approximately a 1-ft depth did not trace them to the presumed parent plant. Seedlings had no evident runners and showed the presence of cotyledon scars or the cotyledons themselves. Each plant with a diameter of 0.5 cm or less was classed as either a sucker or true seedling,

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TABLE 1

CHI-SQUARE STATISTICAL COMPARISON OF THE SEVEN STRUCTURAL ANALYSIS SITES IN KŌKE'E, KAUA'I

SITE NUMBER	LOCATION	χ^2 VALUE	SIGNIFICANCE
2	Po'omau Canyon Trail	28.75	$p = 0.001^*$
3	Honopū Trail	24.45	$p = 0.001^*$
4	Kumuela A	20.26	$p = 0.05$
5	Waininiua Trail	73.39	$p = 0.001^*$
6	Kumuela B	19.30	$p = 0.05$
7	Kumuela C	20.90	$p = 0.05$

*A significant p value indicates that the frequency-diameter size class distribution differs significantly from that of site 1 in the Alaka'i Swamp area.

in an attempt to determine how much of the reproduction is sexual and whether this differs for regions with natural and periodically harvested seed supply.

RESULTS AND DISCUSSION

A structural analysis is designed to determine whether a species is reproducing successfully in its natural environment. If there are sufficient numbers of individuals in smaller size classes and the size-frequency relationship follows a negative exponential law, then it is assumed that the population is maintaining itself (Mueller-Dombois and Ellenburg 1974). The presence of individuals in each size class indicates that Mokihana has been maintaining itself through recent history. The distribution of individuals in 12 diameter size classes for the seven sites in the Kōke'e area is shown in Figure 1. Site 1 was chosen as the area where effective reproduction was expected, not only because of its remote location, but also because the individuals are distributed in all size classes less than 18 cm in diameter. Each site was compared to this site and a chi-square value was calculated using site 1 as the norm.

There is a significant difference in the distribution of individuals in the various size classes in sites 2, 3, and 5 when compared to this site (Table 1). Examining the histograms may explain where the variation arises. Figure 1 shows that at site 1 in the Alaka'i Swamp area the distribution of individuals follows an inverse J-shaped curve. There are more individuals with small diameters and the number of individuals decreases logarithm-

ically as the size class increases. Such a curve is indicative of successful reproduction. Disturbed sites 2 and 7 follow the same general pattern, yet the number of plants in the seedling class (0–2 cm) constitutes a smaller percentage of the total than in site 1. Whether this indicates a lack of reproduction or destruction of seedlings by some extraneous factor is difficult to determine. Sites 3, 4, and 6 seem to follow the inverse J-shaped distribution; however, sites 3 and 4 lack individuals in some of the larger, presumably reproductive, size classes. This could possibly represent recent colonization of these areas by Mokihana, indicating that many plants have not had time to develop into mature trees. In contrast, there are plants in all size classes between seedlings and 18-cm diameters in the Alaka'i Swamp site, an area probably populated by Mokihana for some time. The distribution of plants into size classes at the undisturbed Waininiua site (site 5) is unique. This area has an abundance of individuals in the seedling class and a distinct lack of plants in the 10–20-cm diameter classes. This suggests a history of temporary disturbance in reproduction in this area; apparently, for some time no individuals were established. After this time the environment must have changed again, as there are many individuals of 2–10-cm diameters. At present this area appears to be excellent for germination, as indicated by the large number of seedlings. The area where most of the seedlings are found is an open clearing with little undergrowth and abundant light. The cover has been disrupted by the death of a large *Metrosideros* tree, so that more light is allowed into this area than is normal in the

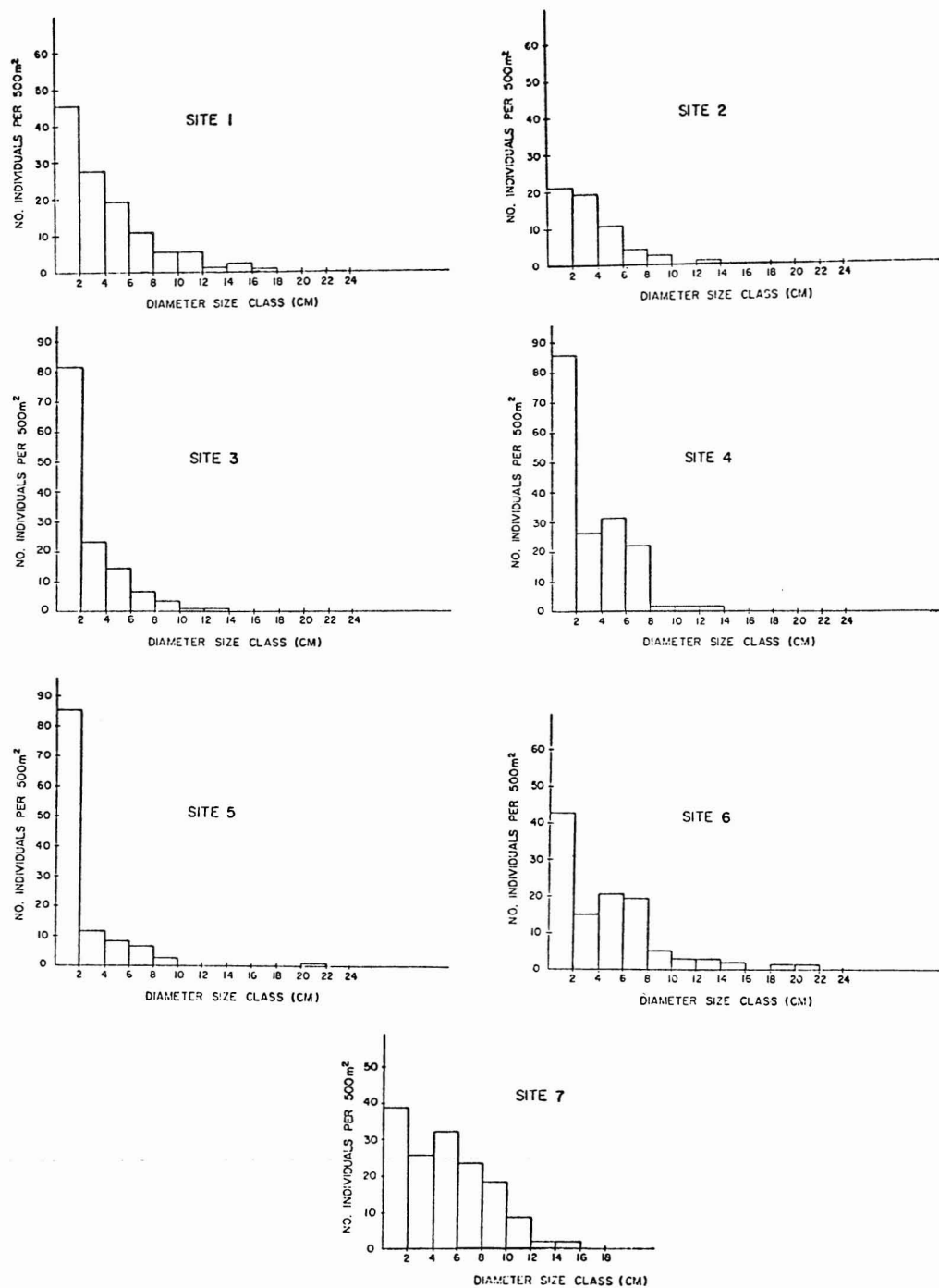


FIGURE 1. Frequency distribution of *Pelea anisata* by diameter size classes in seven sites within the Kōke'e forests, Kaua'i.

TABLE 2

MODE OF REPRODUCTION OF *Pelea anisata* IN DISTURBED AND UNDISTURBED AREAS OF KŌKE'E, KAUA'I

SITE TYPE	NUMBER ASEXUAL	%	NUMBER SEXUAL	%	TOTAL
Undisturbed (1, 3, 5)	31	26.49	86	73.50	117
Disturbed (2, 4, 6, 7)	28	27.18	75	72.81	103

Kōke'e forests. It is reasonable to speculate that the lack of dense ground cover often seen in Mokihana stands and the increased light at this site enhances seedling reproduction.

The second part of this study assesses the relative importance of sexual and vegetative reproduction in Mokihana. Human activity in sites 2, 4, 6, and 7 apparently does not alter the proportion of sexual and asexual reproduction occurring there. In fact, the percentage of vegetative and sexual reproduction in these disturbed sites is compared to undisturbed sites (1, 3, and 5) in Table 2; no significant difference in the proportion was seen. Overall, there is more reproduction from seed (73.16 percent) than from vegetative sources (26.84 percent) in these populations of Mokihana.

In summary, Mokihana appears to be reproducing sufficiently for its own maintenance, and it does so principally by seed,

despite harvesting by humans and competition by introduced exotic plants.

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